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17087 P. Reimplantation of Eyes in Fishes (*Bathygobius soporator*) with Recovery of Vision.*

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The early demonstration by Matthey,[1] that the grafted adult urodele eye is capable of recovering visual function has since been extensively confirmed.[2] With regard to fishes and the anuran amphibians, on the other hand, repeated failure of numerous attempts by various investigators to obtain visual recovery after eye transplantation, even in young tadpole stages, has given rise to the impression that the optic nerve of the grafted eye in these forms lacks the power for functional regeneration.[2]

Recently, however, the writer was able to show that good visual recovery can be

* The experiments were conducted at the Lerner Marine Laboratory of the American Museum of Natural History, at Bimini, British West Indies. They were aided by a grant from the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago.

1 Matthey, R., *Compt. rend. Soc. Biol.*, 1926, **94**, 4.

2 Stone, L. S., *Trans. N. Y. Acad. Sci.*, 1941, **3**, 208.

obtained after optic nerve section in tadpole and adult frogs,[3,4] and also after eye transplantation when the transplantation is performed near the onset of metamorphosis.[4] This, plus current findings that the optic nerve of teleosts likewise is quite capable of good functional regeneration after severance[5,6] and even, in one case, after eye reimplantation,[6] prompted a further attempt to secure visual recovery after eye transplantation in fishes.

Experimental. The goby was selected because of its small size and comparative hardiness to surgical trauma and low oxygen tension. The specimens were gathered during February from tide pools on North Bimini. A total of 22 animals, ranging in length from 14 to 29 mm were anesthetized in a 1.5% solution of urethane and operated upon out of water under a dissecting microscope. The left eye was first removed through a dorsal incision in the roof of the orbit. Through a similar incision in the right orbit, the right optic nerve and extraocular muscles were severed. The eyeball was then lifted out of the orbit and cut completely free from all blood vessels and other connections. Any blood clots that formed in the orbit were carefully removed with cleansing tissue before the eye was replaced. In these preliminary experiments only the right eye was reimplanted and it was always replaced in its own orbit and as nearly as possible in its original orientation. These fish, like the frog tadpole, possess a free external cornea which was left intact and which helped to hold the eye in position after its reimplantation.

After the operation the fish were placed in an aquarium with running sea water in a darkroom on the supposition that retinal metabolism might be somewhat reduced in darkness and that this might be beneficial during the early post-operative period while circulation was being reestablished. Beginning on the 6th day after operation the darkroom was lighted for 10 to 20 minutes each day for feeding the fish and for extraneous purposes. On the 21st day the fish were shifted into two aquaria in the light with standing sea water that was changed every 4 days.

When the animals were examined on the 9th day after operation, the external features of the eye appeared quite normal and eye movements were present in several cases, but there was no sign of vision at this time. When tested again on the 27th day, 2 cases displayed unmistakable evidence of visual recovery. They rose off the bottom and swam directly upward approximately 100 mm toward a small piece of bait less than 4 mm in diameter dangled on the end of a fine silk thread. By the 37th day, 7 of the 16 fish which were still alive had come to perform regularly in this manner. Similar responses were never observed in blind gobies. The accuracy with which those with vision were able to locate small stationary lures indicated that the regenerated fibers had restored their central connections in an orderly manner just as occurs after simple optic nerve section.[5] In control tests in which the bait was presented outside the glass walls of the aquarium all 7 cases responded in typical fashion attempting to reach the lure through the glass. Those which recovered vision measured in total length 16, 16, 18, 22, 24, 25, and 29 mm respectively.

Following anesthetization with urethane on the 38th day, all the heads were fixed in Bouin's solution and were later prepared for microscopic study by a modification of the Bodian Protargol method.[7] Patches of retinal degeneration, particularly in the ganglion cell and inner plexiform layers, were found in all cases but were especially marked in those that failed to recover vision. At some points all retinal layers had disintegrated. In those that recovered vision, a large regenerated optic nerve was present, the fibers of which were easily traceable into the optic tectum of the mesencephalon. Similar regenerated optic nerves were also found in 2 of the cases in which visual feeding reactions had not yet appeared at the time of sacrifice.

[3] Sperry, R., *J. Neurophysiol.*, 1944, **7**, 57.
[4] Sperry, R., *J. Neurophysiol.*, 1945, **8**, 15.
[5] Sperry, R., *Physiol. Zool.*, 1948, **21**, 351.
[6] Rasquin, P., *Physiol. Zool.*, 1949, **22**, 131.
[7] Sperry, R., and Miner, N., *J. Comp. Neurol.*,

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